

Real-Time, Interactive Echocardiography Over High-Speed Networks: Feasibility and Functional Requirements



Cleveland Clinic Foundation staff members conduct an echocardiographic examination at the NASA Lewis Research Center in Cleveland, Ohio, and transmit the live video and audio through the NASA Research and Education Network (NREN) to the NASA Ames Research Center in Mountainview, California, where the examination is remotely interpreted by another cardiologist.

Real-time, Interactive Echocardiography Over High Speed Networks: Feasibility and Functional Requirements is an experiment in advanced telemedicine being conducted jointly by the NASA Lewis Research Center, the NASA Ames Research Center, and the Cleveland Clinic Foundation. In this project, a patient undergoes an echocardiographic examination in Cleveland while being diagnosed remotely by a cardiologist in California viewing a real-time display of echocardiographic video images transmitted over the broadband NASA Research and Education Network (NREN). The remote cardiologist interactively guides the sonographer administering the procedure through a two-way voice link between the two sites.

Echocardiography is a noninvasive medical technique that applies ultrasound imaging to the heart, providing a "motion picture" of the heart in action. Normally, echocardiographic examinations are performed by a sonographer and cardiologist who are located in the same medical facility as the patient. The goal of telemedicine is to allow medical specialists to examine patients located elsewhere, typically in remote or medically underserved geographic areas. For example, a small, rural clinic might have access to an echocardiograph machine but not a cardiologist. By connecting this clinic to a major metropolitan medical facility through a communications network, a minimally trained technician would be able to carry out the procedure under the supervision and guidance of a qualified cardiologist.

Although many telemedicine requirements can be satisfied by the transmission of still images (e.g., x-ray photographs and mammograms), the challenge of procedures like echocardiography is that high-resolution, moving images must be transmitted in real time.

The main problem is bandwidth. The analog video signal produced by an echocardiograph machine requires a digital transmission bandwidth of just over 200 megabits per second (Mbps), and future three-dimensional echocardiograph equipment may require even more. Although it is possible to obtain sufficiently large telecommunications links, they can be prohibitively expensive. More importantly, they are simply not available in many parts of the world, including parts of North America. In fact, in most underdeveloped regions, it is difficult to find links approaching even 1 Mbps.

Since a major goal of telemedicine is to bring high-quality health care to underdeveloped areas, there is a need to transmit medical image data from outlying clinics to major health care facilities using whatever telecommunications links might be available--almost certainly far below the range of 200 Mbps! For moving images, such as echocardiographs, this requires the use of image compression techniques to squeeze the image data stream down to a manageable size while at the same time ensuring that the color, resolution, motion, and overall diagnostic quality of the image remain relatively unimpaired. In addition, since a compressed video stream is, in general, more easily degraded by transmission errors than an uncompressed stream, the interaction between the type of compression used and the link over which the compressed image is carried becomes extremely important. The NASA/Cleveland Clinic NREN test examined the interaction between a specific compression algorithm (MPEG-2) and a specific type of communications protocol (asynchronous transfer mode, or ATM).

In this demonstration, the fiber-optic-based NREN provided a controlled engineering testbed for assessing the clinical feasibility of remote echocardiography. The research team was able to adjust MPEG-2 compression ratios along with ATM quality-of-service parameters (cell loss ratio, cell error ratio, and cell delay variation) to examine their effects on the diagnostic quality of the received image. Future experiments will use NREN to examine other compression techniques, such as wavelet compression, and different types of hybrid network architectures and protocols.

Lewis contact: David A. Foltz, (216) 433-5077, David.A.Foltz@grc.nasa.gov

Author: Eric A. Bobinsky

Headquarters program office: OASTT

Programs/Projects: NREN, Next Generation Internet Architecture, Space Station Echocardiography, Telemedicine